# SCR Catalyst Management: Lessons Learned

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# About us

- **Enel Produzione spa: Power Utility Co. created in 1998 from Enel spa**
- **CESI spa: Services & Research Co. issued in 1956, and reorganised in 2000, merging the major part of the Enel spa R&D Division**

# About Enel Produzione spa

- **Largest power generation Co. in Italy**
- **Shared 100% by Enel spa**
- **Installed capacity: 40,750 MW**

  **26,684 MW thermal & 14,065 hydro (as in 2001)**
- **Power generation: 125,3 TWh (as in 2000)**
- **Approx. 10,000 employees**

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# About Cesi spa

- Services & Research Center
- Shareholders 44 % by Enel Group Co., 10 % italian ISO, other (utilities, industries, etc.)
- Testing & Certification, Environment, Power Generation, T&D Networks, End Users and Renewables
- Approx. 1,000 employees

# $NO_x$ emissions in Italy/1

- **Approx. 2Mton per year**
- **16 % due to power generation (as in 1994)**
  - Fossil fired generation 220 TWh (79 %) (as in 2000)
    - **Coal 26 TWh**
    - **Oil 86 TWh**
    - **Natural gas 100 TWh**
    - **Other 8 TWh**

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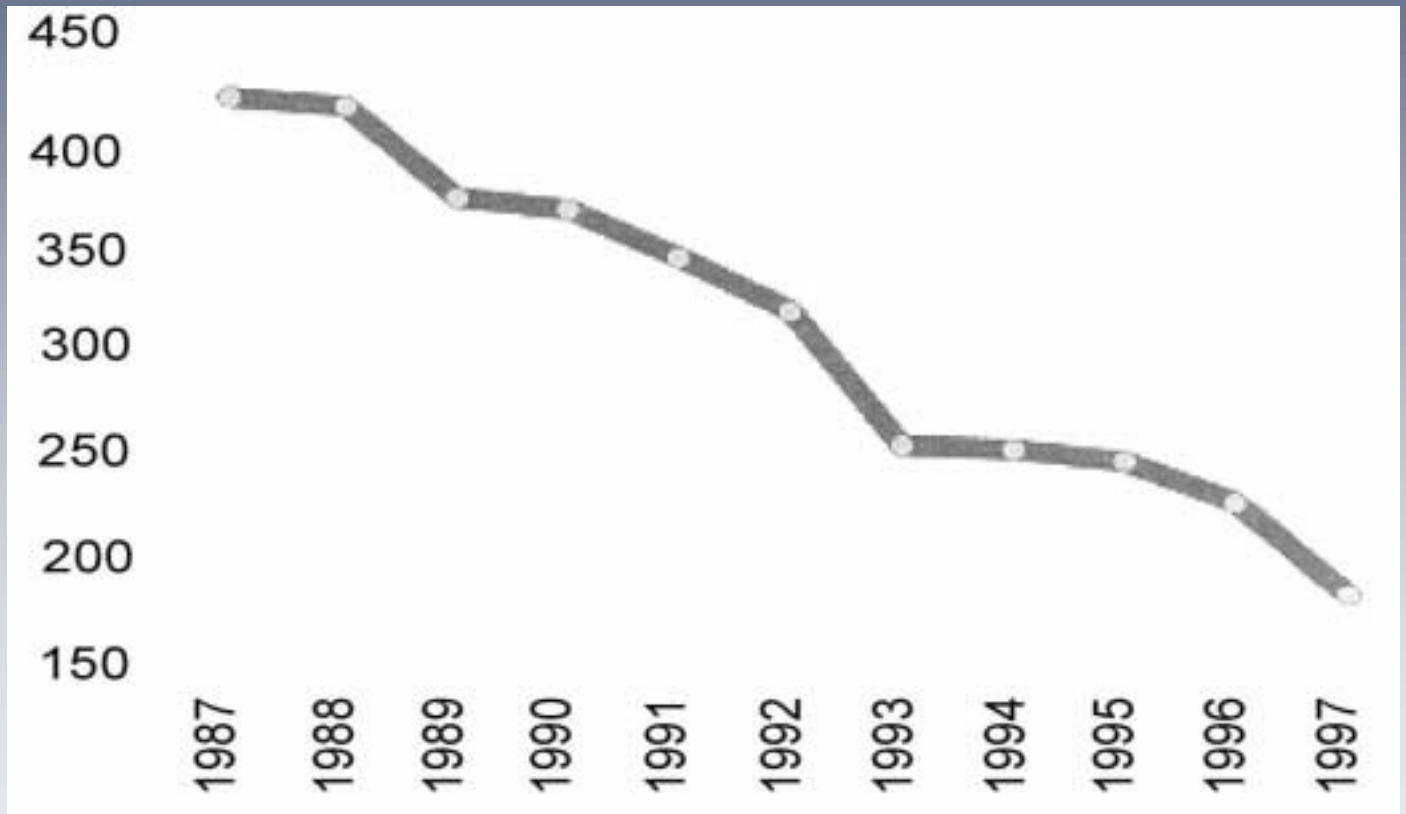
# $NO_x$ emissions in Italy/2

## Enel spa $NO_x$ emission (kton)

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# $NO_x$ emissions in Italy/3

- Emission limits fixed by law from 1989 in reception of EU Directives
- 200 mg/$Nm^3$ for each power plant
- In few cases, local authorities imposed lower limits
- $NO_x$ emission trading not yet acknowledged in Italian legislation

# SCR technology in Italy /1

- In early '90s Enel spa started a large environmental program in order to comply new environmental regulatories
- All existing power stations, exceeding 500 MWth, has been submitted to environmental retrofittings
- For NOx control combustion modification and SCR technology have been selected

# SCR technology in Italy /2

- 12 fossil fired power stations (30 units) have SCR denoxing systems
- 8 of these (22 units) are owned
- a few SCR denoxing systems are also in operation in waste incinerators, refineries, etc.

# SCR technology in Italy /3

- Enel spa issued a technical specification for SCR installation
- Retrofitting works have been contracted to SCR manufacturers
- European and Japanese companies resulted as catalyst suppliers

# SCR technology in Italy /4

## Enel tech spec asked for

- Different fuels: coal, oil and NG
- NOx reduction: 80%
- $SO_2$ to $SO_3$ conversion: 1.0 >> 0.8%
- Ammonia slip: up to 5 ppm
- Catalyst type: honeycombs or plates
- Pressure drops: as low as possible

# SCR technology in Italy /5

- SCR reactors (all but one) are installed in high-dust configuration
- Usually 2 reactors in parallel are installed for each boiler
- Enel Produzione has 42 SCR reactors

# SCR technology in Italy /6

- SCR reactor has typically 3 catalyst layers (one more is empty)
- Soot-blowers are installed. They usually work with dry steam
- Guide vanes, rectifier, and dummy layer are installed too

# SCR technology in Italy /7

- Enel Produzione has in service more than 7,500 $m^3$ of catalyst
- 3,900 $m^3$ (52 %) are plate type, from Hitachi (Japan)
- 3,600 $m^3$ (48 %) are honeycomb type, from Frauenthal (Austria), Siemens (Germany) and KW Huls (Germany)

# SCR operating experiences /1

- SCR technology is effective in NOx control
- SCR technology is quite simple to manage
- Nevetheless SCR DeNOx must be controlled

# SCR operating experiences /2

**Key elements are:**

- **Catalyst**
- **Ammonia injection**
- **Soot blowers**

**Catalyst is "consumable"**

# SCR operating experiences /3

- To manage SCR technology some proper know how is needed
- Independent expertise, different from catalyst suppliers, can help in saving money
  - assessment of equipment performances
  - catalyst replacement strategies

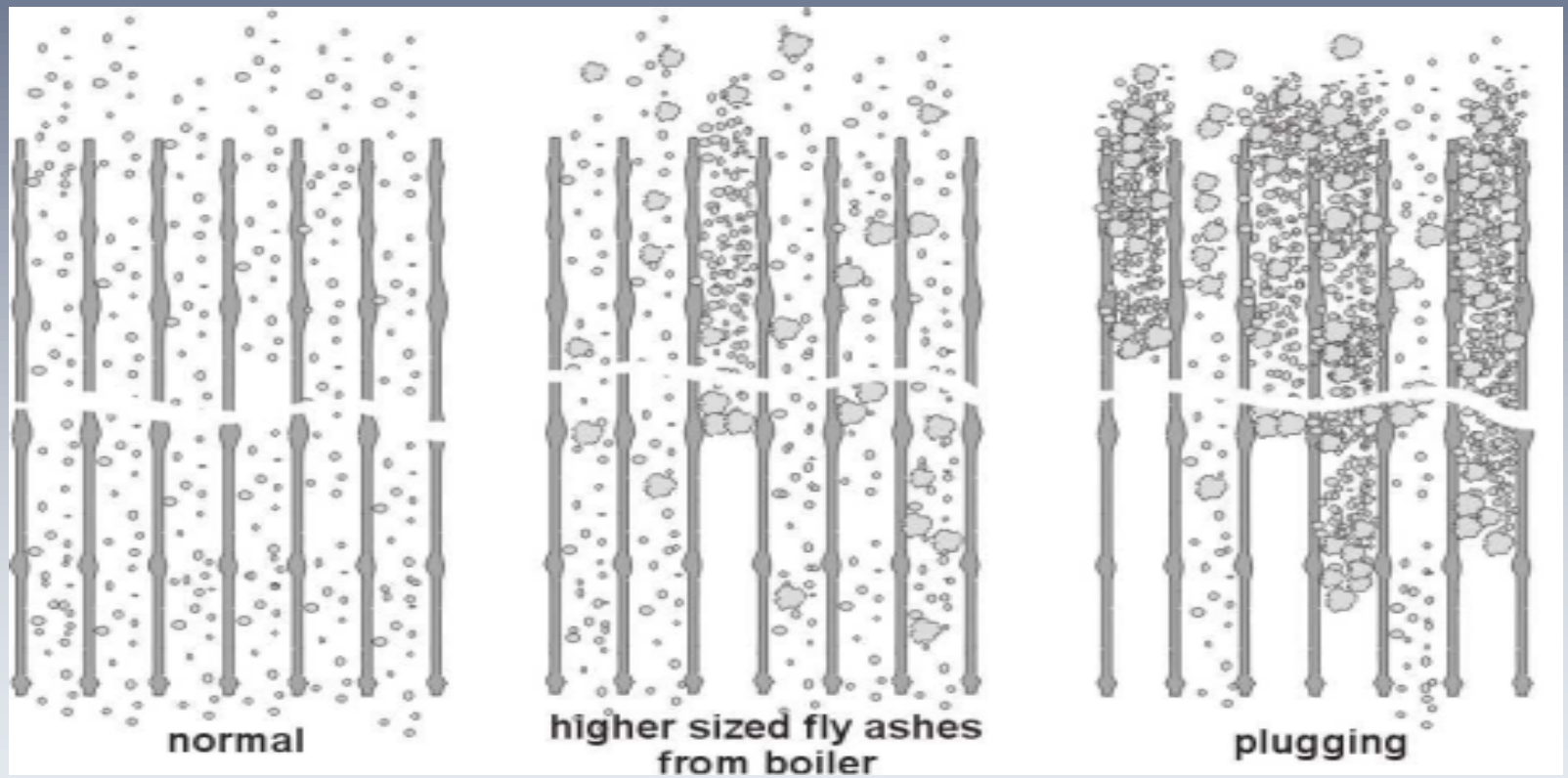
# SCR operating experiences /4

- Operating in "as spec conditions", catalyst life resulted higher than designed
- Catalyst can support "out of design "operating conditions
- Catalyst life is strictly correlated with boiler combustion

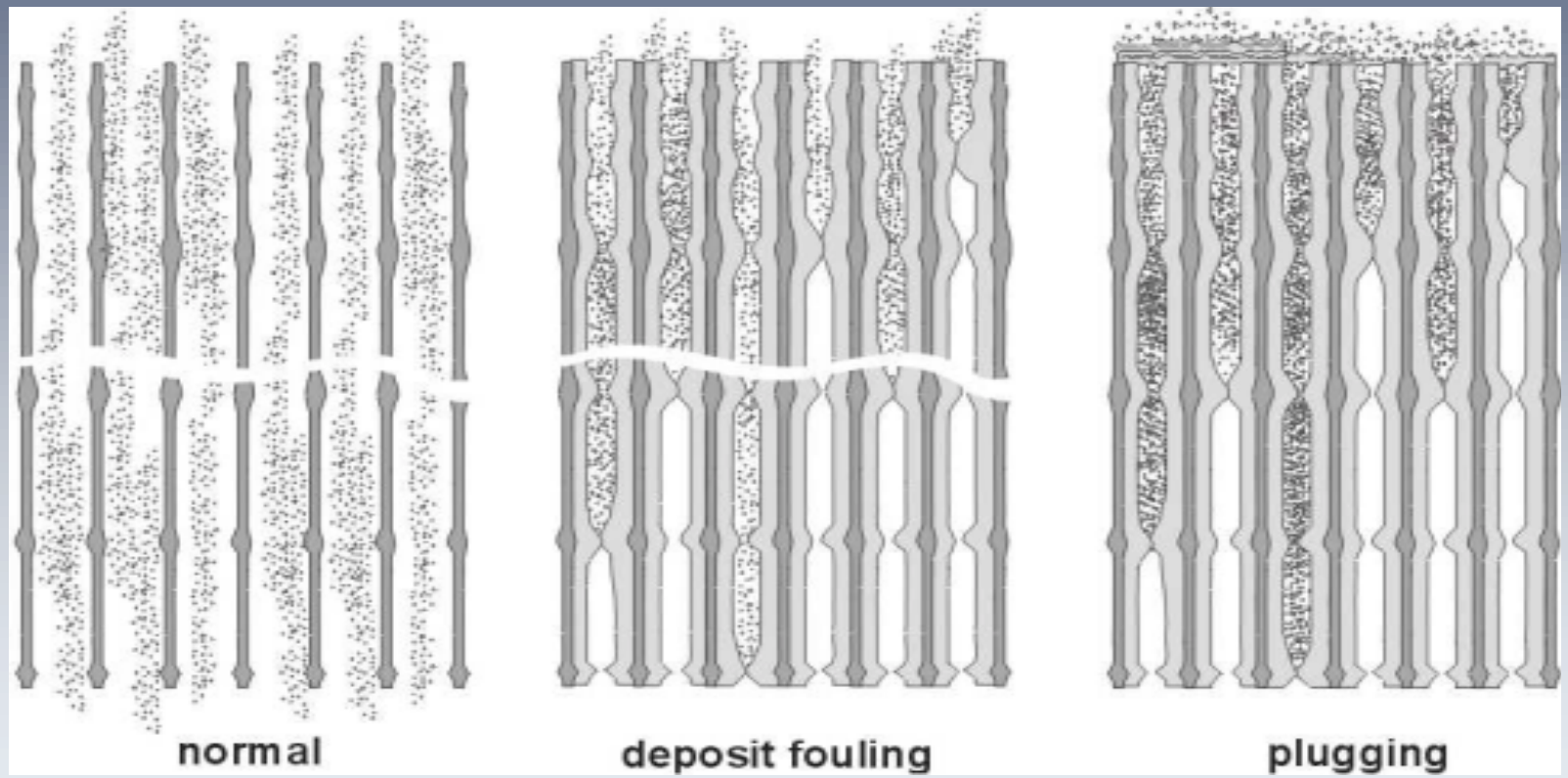
# SCR operating experiences /5

- Catalyst plugging is still a problem
- Catalyst deactivation seems to be lower than expected
- Catalyst loose performances because of fouling
- Keeping catalyst clean is the major problem affecting SCR operation

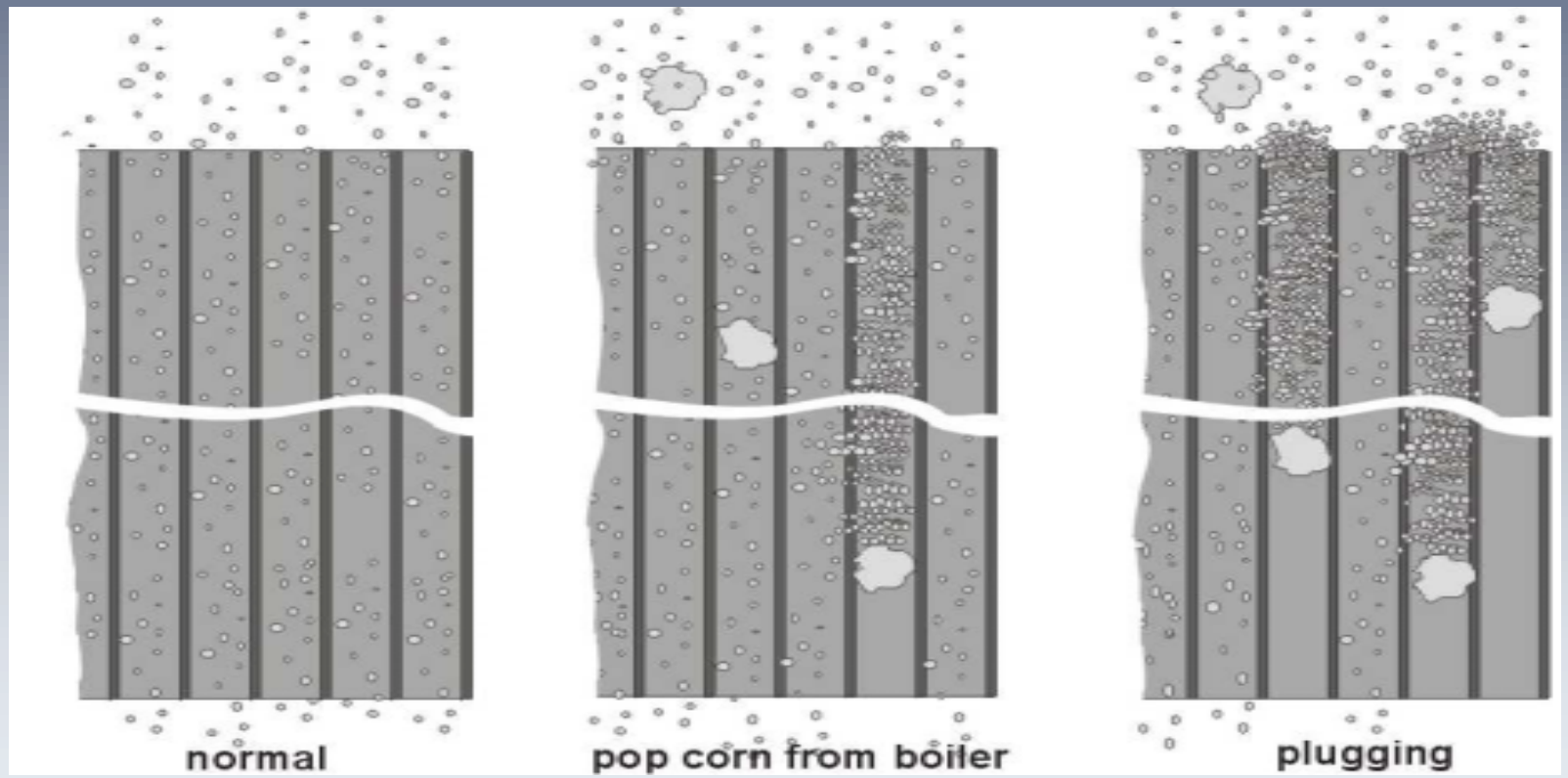
# SCR operating experiences /6
# Higher sized fly ashes plugging



# SCR operating experiences /7
# MgO injection plugging



# SCR operating experiences /8
# "Pop corn" plugging



# SCR operating experiences /9
# Ammonia injection

- Stripped in column and mixed with hot air
- Rate of injection depending from the $NO_x$ content
- Automation of ammonia injection is a relevant problem in some power plants

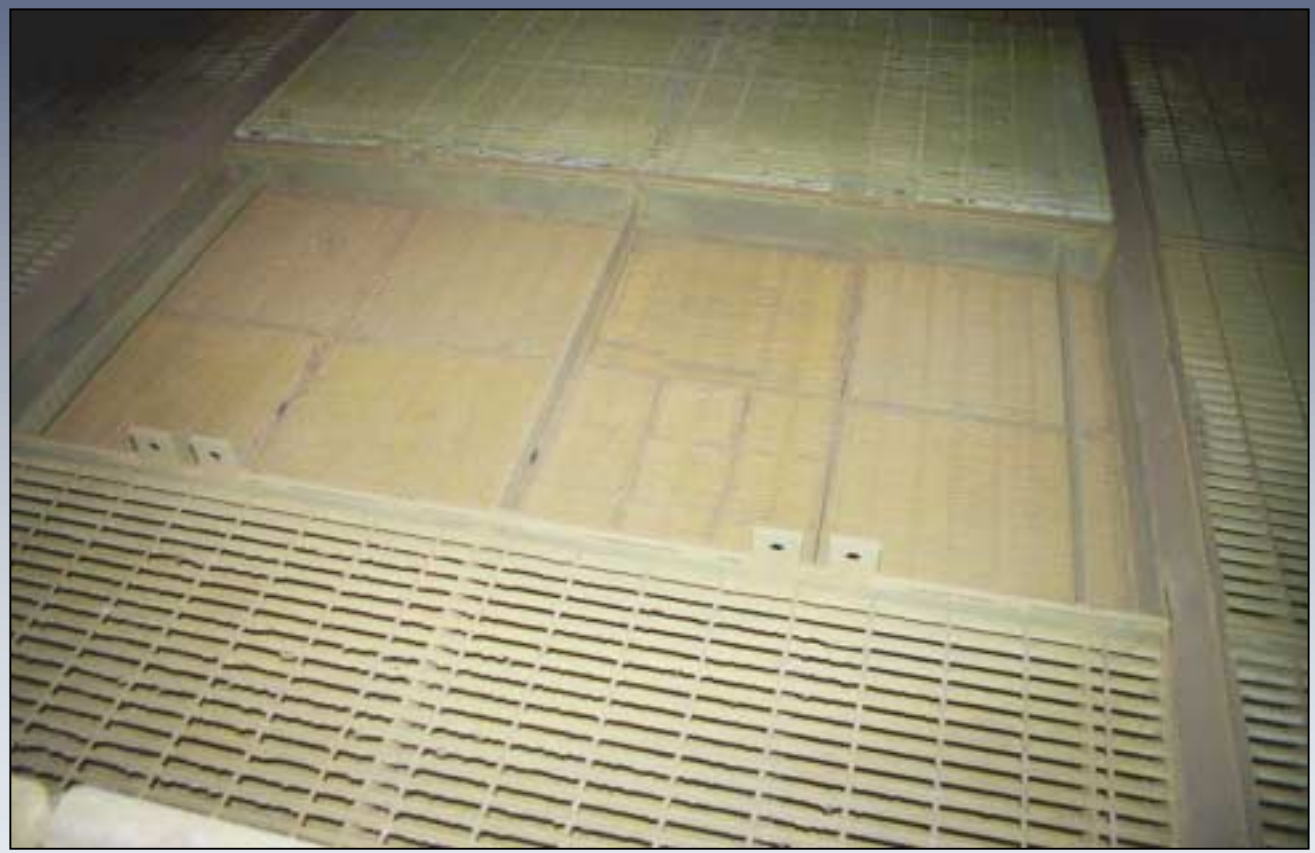
# SCR operating experiences /10
# Soot blowers

- Because of fouling (>>> plugging) soot blowers are key elements
- Frequency of use depends on pressure drops
- In coal fired power plants the frequency is up to once a shift
- In some cases plant managers tend to reduce the use of soot blowers in order to save steam/water

# SCR operating experiences /11
# Changing fuel

- Switching fuel from coal to orimulsion, and to coal/orimulsion co-combustion, can be supported by SCR catalyst
- $SO_2$ to $SO_3$ conversion is the main issue. Because of its volume dependence, one catalyst layer has been removed
- An increase in fouling resulted

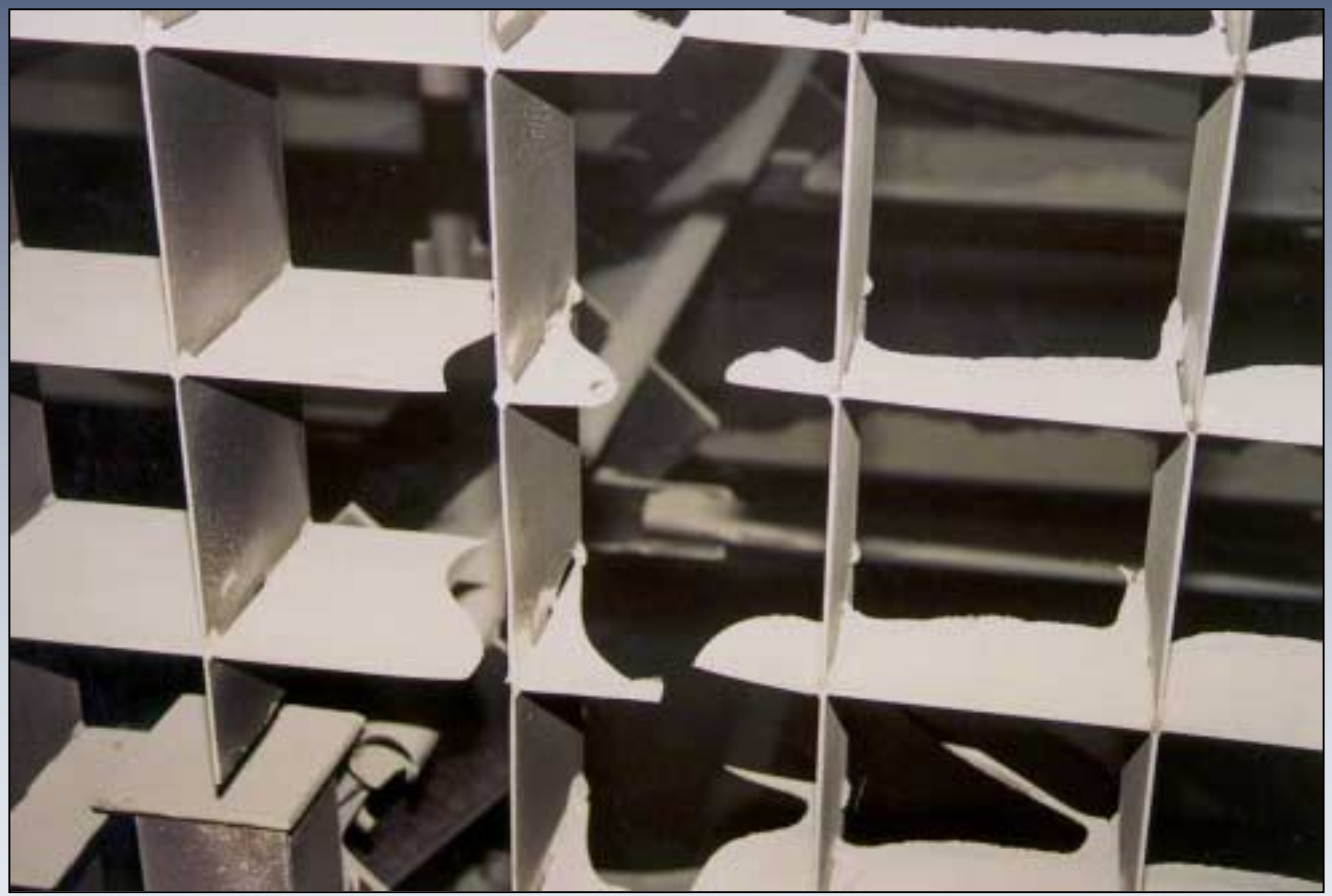
# SCR operating experiences /12



# SCR operating experiences /13

# SCR operating experiences /14

# SCR operating experiences /15



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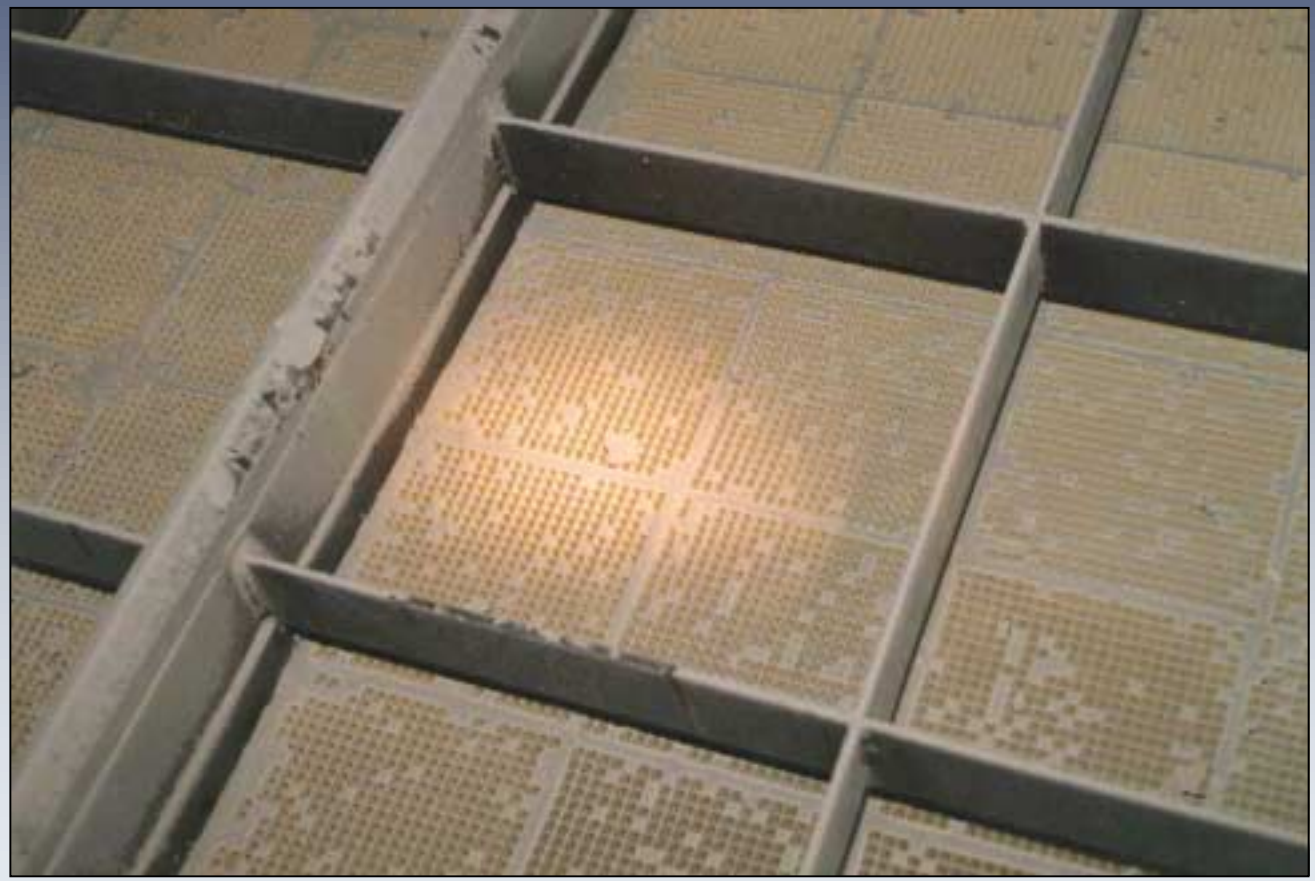
# SCR operating experiences /16



# CESI services /1

- CESI acts as independent consultant
- Dedicated laboratories and facilities for catalyst assessments
- KH for catalyst management and cleaning

# CESI services /2

- Denoxing reactor inspection
- Denoxing reactor asset measurements
- Ammonia slip measurements
- Catalyst sampling
- Catalyst performance assessment
- Catalyst deactivation measurements
- Catalyst cleaning and regeneration

# CESI services /3

# CESI services /4

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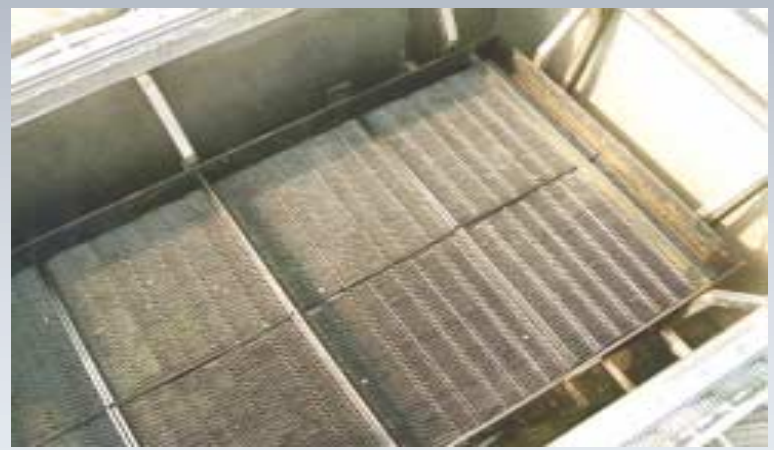
# CESI services /5



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# CESI services /6

# Lessons learned /1

- If proper operated, catalyst life is higher than expected
- Some denox reactors have been designed and installed with more catalyst then needed. This acts as a "reserve"

# Lessons learned /2

- Frequent reactor inspections and dedicated programs for checking catalyst performances, really help plant manager in delay catalyst replacement
- Sampling catalyst during plant shut-down is mandatory
- Micro-reactor catalytic measurements are enough for catalyst assessment

# Lessons learned /3

- Catalyst cleaning and regeneration is a valuable option before buying new catalysts
- SCR cleaning and regeneration technologies should be implemented after selection on cost effective base (each degradation phenomena should require different cleaning technology)

# Lessons learned /4

- Correct management of SCR technology can result in saving money
- Utilities previous experiences as well as independent consultants experiences are useful in avoiding errors and better selection of remedies